alternate potential differences are transformed up from about 100 to 2000 volts; and to enable the transmission to be effected with three wires instead of four, Messrs. Schuckert arrange the transformer at each end of the line as shown symbolically in Fig. 13. Hence, if the currents produced by the dynamo be represented by $A \sin\theta$ and $A \cos\theta$, the currents in the main wires, W_3, W_1, and W_2, will be represented by $A \cos(-\theta)$, $A \sin(-\theta)$, and $A\{\sin(-\theta) + \cos(-\theta)\}$ respectively.

The actual method employed by Messrs. Schuckert for winding this special transformer, as well as its appearance when completed, are seen from Figs. 15 and 16. This transformer, then, instead of consisting of merely a double ring of laminated iron as indicated in the symbolical diagram, Fig. 13, may be regarded as being composed of a connected series of laminated iron rings, each of a wedge-shaped cross-section.

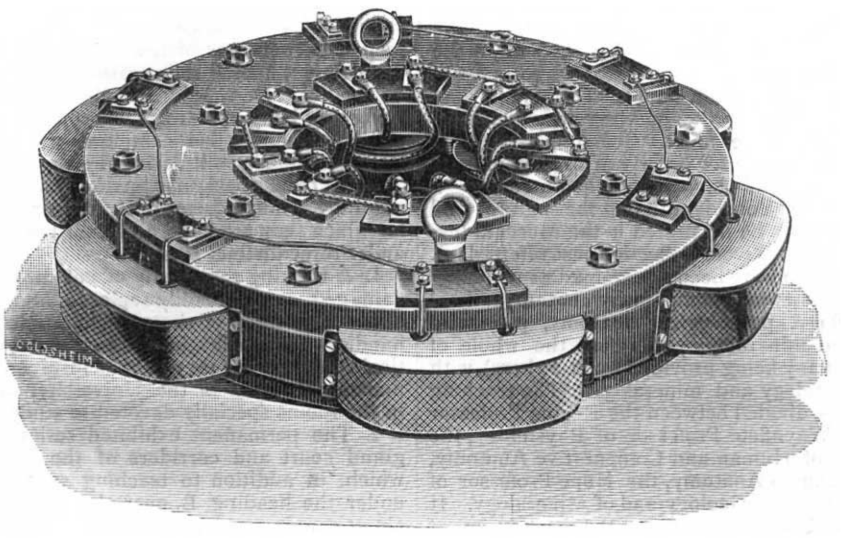

Fig. 16.—Schuckert two-phase alternate current transformer (completed).

(*To be continued.*)

THE OXFORD UNIVERSITY MUSEUM.[1]

THE following memorandum is based, not only upon observations made during a recent visit to Oxford, but also upon a fairly intimate knowledge of the origin and progress of the different departments of the Museum, acquired at various intervals of time extending over more than thirty years.

In entering upon the consideration of the subject which you have referred to me, it will first be necessary to define the purposes for which the Museum is maintained. These I take to be somewhat manifold, but they may be classed as follows:—

A. The first and main purpose is undoubtedly to assist in the educational work of the University, by illustrating the teaching of the professors and lecturers.

Besides this, however, it subserves, to a greater or less degree, other and what may be considered, as compared with the first, secondary, but nevertheless important functions. These are—

B. The exhibition of a collection, arranged in a systematic, orderly, and attractive manner, open to the inspection, under proper regulations, of all members of the University, and also of residents in and visitors to the town, which shall tend to awaken and keep up an interest in various subjects of which most educated persons, besides those actually engaged at the moment in obtaining instruction, desire to possess some knowledge. Such a collection is a most legitimate adjunct to the University as a place of general culture.

C. Certain collections have already, and possibly will in future, become added to the general Museum, the aim and scope of which reach beyond either of the above, being of value, not to the ordinary student, not to the man or woman of average general culture, but only to the advanced student who wishes to enter seriously into the pursuit of some special branch of knowledge. Such is the Hope Collection of Insects, and to a certain extent the Pitt-Rivers Ethnographical Collection.

It is a grave question how far such collections should be maintained at the cost of the University. On the one hand, they must be a cause of expense, without which no collection of any value can be maintained; and the larger and better ordered they are, the greater must be the cost of maintaining them. Unless properly cared for, not only as regards actual preservation of the objects contained in them, but also as regards the continual re-arrangements and augmentations necessitated by the advance of science, they will become comparatively valueless in the course of time. If the care of many such collections were undertaken unaccompanied by special endowments for their maintenance, the burden would become such as only a national institution could afford.

On the other hand, looking at the University, not merely as a place for the education of youth, but also as a centre of culture for the whole country, the possession of some such collections is of great importance. As they contain in them objects which can be found nowhere else, they attract men of learning and science, not only from other parts of the country, but also from distant places, to visit the University, or even to become permanent residents. The value of collections of rare books, even upon subjects interesting to scholars whose numbers are very limited, have long been recognized. From the same point of view, special collections of rare specimens of natural history or works of art may take their place in the general scheme of a University Museum, but the care of such collections should not be undertaken without full consideration as to whether the means will be forthcoming to maintain them in a state of efficiency.

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[1] Prof. Flower's Report to the Committee on Collections appointed by the Delegates of the University Museum, Oxford, dated March 14, 1891.

I have alluded to the Pitt-Rivers Collection as coming partly under this head, but, admirably and instructively displayed as it now is, it may also be considered as belonging to my second category; and the numerous human interests awakened by a study of its contents, and the many branches of culture it comes in contact with, make it an adjunct to the Museum, of the great importance of which no one should entertain a doubt. I should be glad to remark, in passing, that the building in which it is housed appears to me the most successful, as regards economy of space, capacity for orderly arrangement, and good lighting, of any with which I am acquainted.

The next point for consideration is the nature and extent of the subjects to be illustrated in the Museum (excluding the special Pitt-Rivers Collection just referred to). These seem already to have been determined as including physiology, human anatomy, comparative anatomy, animal morphology, zoology, pathological anatomy, palæontology, geology, and mineralogy; therefore the whole of animal biology (botany being provided for elsewhere), with the addition of geology and mineralogy. The teaching of these subjects is divided between the Regius Professor of Medicine, the Waynflete Professor of Physiology, the Linacre Professor of Human and Comparative Anatomy, the Lecturer in Human Anatomy, the Hope Professor of Zoology, the Professors of Geology and of Mineralogy. It must be recognized by everyone that the boundaries of these subjects are most difficult to define, and must be constantly shifting with the advance of knowledge. For instance, comparative anatomy and palæontology may both be included under the broad general heading of zoology, which without the aid of both can be but imperfectly understood. Whatever dividing lines are drawn between different sections of the collection, identical specimens are often required to illustrate more than one subject. The remains of extinct animals are required to complete the story of their living representatives; they are also required to illustrate the ancient history of the earth, and to define the progress of geological time and the order and succession of strata. The relation between the collections used to illustrate the teaching of the Waynflete, the Linacre, and the Hope Professors, must also be more or less arbitrary and artificial. In all these matters mutual convenience must be studied, and the specimens which lie on the borderland of two subjects should be made in some way available for the teaching of both, otherwise a great duplication will be necessary.

With regard to general administration, it appears to me desirable that there should be a governing body for the whole Museum, comparable to the standing committee of the Trustees of the British Museum, or the Museum Committee of the Royal College of Surgeons, or the Museums Syndicate of the University of Cambridge. The Delegates constitute such a body at Oxford, but possibly their constitution or powers might be modified and more clearly defined than they seem to be at present.

This body should be composed of members of the University specially selected for fitness for the office; seven or nine would probably be the most convenient number, so that representatives may be found upon it of various branches of science included in the Museum, and also some members of general business or administrative capacity. They should meet at occasional and stated intervals, and should determine general questions affecting the Museum as a whole, the relations of its component elements one to another, the allotment of space and the apportionment of the grants for the service of each department, the general control of expenditure, and also the care of the building, furniture, &c. It is not advisable that they should interfere with the details of the arrangement of each department as long as these appear to be satisfactorily carried out. The Keeper of the Museum should be the active executive officer of this governing body, carrying out their views in the intervals of the meetings, and bringing before their notice any subjects which seem to require their consideration.

Each professor, as the representative of the most advanced state of knowledge of his subject, should be the responsible curator of the specimens belonging to his department, having such assistance provided him as may be needful. He should be called upon to present to the governing body an annual report of the condition of the collections under his care, and of the accessions which have been made to it during the year.

The actual specimens in the various collections will naturally arrange themselves, both as regards the purpose for which they are kept, and their mode of conservation, under three distinct classes.

1. A working set, mostly of common objects, which, if damaged, can be readily replaced, and which can be put at the disposition of the ordinary student to examine and handle. Such collections are absolutely essential to practical teaching, but they should form no part of the permanent Museum of the University, and should be kept in the rooms specially devoted to study.

2. The permanent exhibited series displayed in the grand court and corridors of the Museum, the use of which, in addition to teaching students, is referred to under the heading B, near the beginning of this report. Great care is required in selecting and arranging these, as well as in their preservation and display. Every specimen exhibited should have a definite object, and should be so placed that it can be thoroughly well seen. As a general rule they should be so arranged as to show what they are intended to teach without moving them from their places, and if this must be done under proper restrictions, all due precautions should be used that they do not become damaged or destroyed. Although for the purposes of custody, arrangement, and nomenclature, these must be under the care of a particular professor, they are in a certain sense the common property of all who have a right of access to the Museum. This is another reason for not removing them from their places (apart from the injury that might thereby accrue to them) without definite cause, as they should be always available for study, the professors and demonstrators rather bringing their classes to them than removing them to the class-rooms.

3. The collections kept for advanced researches. Although these are not exhibited in the ordinary sense of the word, they should, if retained at all, be kept in a situation and under conditions which make them readily accessible to all who can profit by their examination under suitable regulations. Their preservation is of the utmost importance in the progress of science, as among them are often to be found zoological "types," or the individual specimens upon which the name of the species was instituted, and which must be referred to by zoologists for all future time in cases of difficulty in determining that name. To permit the loss or deterioration of a "type" specimen is a serious offence in the eyes of the zoologist. The Hope Collection abounds in such types.

Nothing more need be said at present about the first and third of these sections of the Museum, but the second, the exhibited series occupying the body of the great hall, requires consideration in a little more detail.

It is divided at present into—

(1) Mineralogy. Of the value and arrangement of this section I am not competent to speak.

(2) Geology. This collection is mainly palæontological, and the arrangement appears to be partly stratigraphical and partly zoological. In many groups the collection is rich, but taking it altogether there appears to be a number of unnecessary duplicates, and much rearrangement is

required to bring it into good exhibition and teaching order. I would suggest that in a collection illustrating *geology* (and not the zoology of extinct animals, so often in museums confounded with that science) the stratigraphical arrangement should be followed as strictly as possible, and also that there should be a good series illustrating dynamical geology, or the processes by which the materials forming the earth's crust have been fashioned and arranged as we now see them.

(3) Animal Biology. This section occupies about two-thirds of the floor space of the Museum, and is at present broken up into various small series involving much repetition and duplication, and also difficulty of finding any particular object or illustration required.

In the middle of the hall is a series of specimens merely showing the external appearance of certain groups of animals, stuffed vertebrates and the shells of mollusks, and stony skeletons of corals, &c. If this collection were incorporated in the general series of animal biology, not only would much duplication be avoided, but a more instructive and scientific exhibition would be provided. Many of the present specimens of this series, especially the mounted mammals and birds, are in such bad condition that they have no educational value—they only mislead instead of teaching; but before destroying them they should all be submitted to the examination of some expert in the group to which they belong, as there may be interesting or rare specimens among them, though their value is scarcely to be recognized by the ordinary observer in their present condition.

The imperfection of any zoological series that does not illustrate extinct as well as recent forms is continually becoming more apparent as science advances; some attempts have already been made to remedy this defect in the zoological series, but a considerable transfer of specimens to it from the department of geology will result in advantage to both.

By a rearrangement of the biological series, with incorporation of the so-called zoological specimens (excluding the Hope Collection, which I presume is always to be kept apart) much economy of space could be effected, and some of the confusion which now appears to exist in this department of the Museum in consequence of the numerous apparently independent series of specimens will be obviated.

The great question of the primary arrangement of the biological collection, whether on the physiological or Hunterian system, or upon a system based upon zoological classification, will have to be carefully considered. Much is to be said for either, but whichever is adopted should follow the method of teaching of the professor and his assistants. The point to be aimed at is that every specimen should be readily found, and be in juxtaposition with other specimens which are related to it, and which should be studied in conjunction with it. As the classification of animals, except as regards the greater divisions, is still a matter of much uncertainty, and continually changing according to the advance of knowledge, or the opinions of individual zoologists, it is not a satisfactory basis for the arrangement of a collection intended to illustrate principles rather than details. On the other hand, the Hunterian system often brings into juxtaposition specimens related only by some remote analogy of function, and having no real correspondence or homology. Probably a zoological arrangement for the main divisions, and one based upon a comparison of organs or systems for the secondary divisions, will, on the whole, be found most convenient.

I am hardly in a position to say how far the Professor of Physiology requires a special collection to illustrate his teaching. Probably the general biological series will supply all that is necessary to refer to in illustration of his lectures, especially as the tendency of modern physiology seems to be to separate itself from morphology, and confine itself more to biological chemistry and dynamics.

Another question which has been raised is, whether human anatomy, as distinguished from general biology, requires a separate section of the Museum, and how the great and important collection of crania of the races of men, which under Prof. Rolleston became one of the special features of the Museum, should be treated and utilized for instruction. These are questions that time will probably solve. Much depends upon the view taken of the duties of the Lecturer on Human Anatomy, whether he should teach upon a broad and philosophical basis, or whether he should aim mainly at enabling his pupils to pass the standard now required by the examining bodies. But this trenches upon the larger and more complex subject of what should be the aim of the University in keeping up a Medical School.

The Pathological Collection will, of course, remain as at present under the care of the Professor of Medicine.

In looking round the Museum at the present time, one of its greatest wants appears to me to be proper labelling. The different sections of the Museum should be distinctly marked off from each other. Every case should have a conspicuous label on the top of it, indicating the nature of its contents. Every specimen should have one indicating why it is there and what it teaches. This will involve a large amount of labour and expense in printing, but it is absolutely necessary, if the collections are to fulfil the purpose for which they are formed. It is a mistake to spend much time, labour, and cost in obtaining, preparing, and preserving a specimen, and then to stop short of the one thing needed to make it of use. Better have fewer specimens in a complete state. A printing press might be established in the building and kept constantly at work, but as it would be difficult to apportion the claims upon its services of the different curators, it might be better to make an arrangement with the University Press by which labels (of a uniform character) for the whole Museum would be printed at a fixed charge, and paid for out of the funds of the department requiring them. As in a large number of cases only a single copy of a label is required, it is possible that some system of type-writing might be more economical, and nearly, if not quite, as effectual.

Of the importance of complete catalogues of every department of the Museum, it would seem almost superfluous to speak, were it not obvious that much is needed in this respect.

Lastly, it appears to me that, although more work-rooms and class-rooms may be necessary for the growing needs of the scientific departments of the University, there is ample space in the present building for some time to come for the exhibited portion of the Museum. The collections are rich, contain many instructive and valuable objects, and do great credit to the zeal and energy of those by whom they have been brought together. What is really required now is, not so much that they should be increased, as that they should be better arranged, better cared for, and that all inferior and defective specimens should be gradually replaced by better ones. Oxford has done very much in past times to initiate and keep up a high standard of museum work, but it must not be overlooked that great advances are being made in this respect, not only in this country but all over the Continent, and the standard is being continually raised. All such work is both laborious and costly, but when done the result is fully commensurate to the labour and expense bestowed upon it. An ill-arranged museum has been well compared to the letters of the alphabet tossed about indiscriminately, meaning nothing; a well-arranged one to the same letters placed in such orderly sequence as to produce words of counsel and instruction.